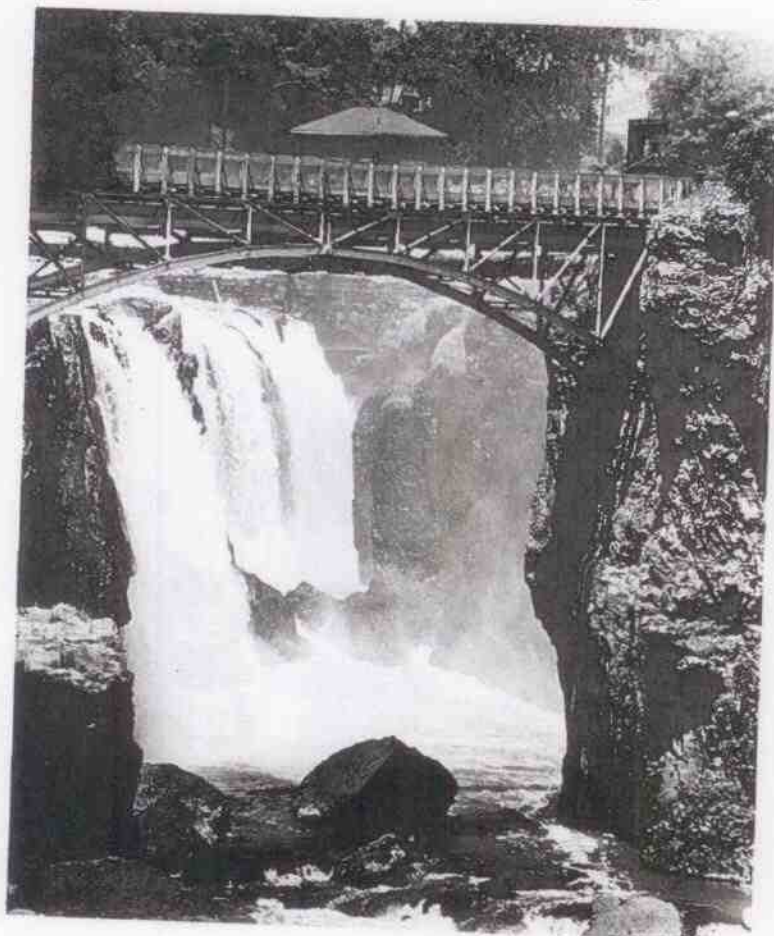


THE
GEOLOGY OF
PATERSON, NEW JERSEY
WITH A FIELD GUIDE



BY LUBOV DRASHEVSKA

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Paterson Museum

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Front cover: A current view of the Great Falls of the Passaic River. Paterson Library Archives, photo by M. Spozarsky.

Back cover: A view of the Great Falls in 1761. British Museum, painted and engraved by Paul Sandby from a sketch by Thomas Pownall.

FOREWORD

This publication is a continuing effort on the part of the Paterson Museum to involve people in the study of their environment. The pamphlet is intended as a geological guide of the Paterson area for people interested in the outdoors but who do not have a sufficient background for the interpretation of the geological features which they encounter. This guide will enable a reader to recognize the ancient lava flows; the traces of mighty movements of the Earth's crust; the evidence of the Ice Age, when large sheets of ice covered the area; and vestiges of other events that happened in the geological past and are now reflected in the rocks seen in the greater Paterson area.

It is hoped that this guide will be useful to elementary school science teachers. They may take students on a field trip and show them in "Nature's Laboratory" things which they have discussed in class. The guide may also be of use to youth leaders who take youngsters on hikes and who try to foster an interest in nature.

ACKNOWLEDGEMENTS

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Thomas Peters, Director of the Museum, who critically reviewed the manuscript;

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SOME DATA ON THE GEOLOGICAL PAST OF THE PATERSON AREA

Geologists who have worked in the Paterson area have learned about its geological past as reflected in the rocks and landforms. The rocks which can be seen here are about 190-205 million years old and were formed during the Triassic Period which belongs to the era in the Earth's history commonly known as the "Age of Dinosaurs." At that time, the Earth's crust in the area underwent changes causing a deep basin to be formed. Very slowly, during the course of several million years, this basin was gradually filled with sand and mud carried into it by rivers. Then, lava flowed out repeatedly on the Earth's surface through deep fissures in the rock and solidified to form a rock known as basalt. This volcanic activity was interrupted and again sand and mud accumulated on the lava rock for hundreds of thousands of years. Then a second volcanic episode took place, and later, a third one.

Many climatic changes occurred in the Paterson area during the millions of years of sand and mud accumulation and lava outpourings. Muddy plains and swamps existed during the wet periods. Dinosaur footprints were found in rocks formed from mud in localities close to Paterson. To the best of our knowledge, no dinosaur footprints are recorded to date in Paterson rocks. However, there is always the possibility that a sharp observer will discover some.

According to the hypothesis now supported by most geologists, the appearance of the above mentioned deep basin (rift) in the Earth's crust, and later of fissures through which the lava poured (now observed as basalt rock in the Paterson area) were associated with the splitting of a supercontinent which existed at an earlier time in the geological past. It is supposed that around 190 million years ago, Africa split from North America and the Atlantic Ocean formed. It just happened that the line of splitting of the supercontinent crossed today's Paterson area and left its evidence in the form of large masses of ancient lava.

Lava sheets and layers of sandstone and shale were originally deposited as horizontal sheets. Then at the close of the Triassic Period (about 190 million years ago) or during the following period known as the Jurassic Period (about 136-190 million years ago), mighty deformations of the Earth's crust occurred in northeastern North America, including the rocks of the Paterson area. The Earth's crust was uplifted east of today's New Jersey and rock layers lying west of the highest axis became tilted to the west. Evidently, earthquakes occurred, large fractures broke the rocks, and parts of the rock masses slid down along one side of the fractures forming faults. Both faults and tilted rocks can be observed in the Paterson area.

A GLIMPSE OF THE LANDSCAPE AROUND PATERSON AND OF ITS FORMATION

Garret Mountain, with its gray cliffs, is a natural landmark in Paterson. Its highest elevation above sea level is 533 feet.

Garret Mountain is a part of the ridge called the First Watchung Mountain which stretches for some 48 miles. The Second Watchung Mountain runs parallel to the First along its western edge and is seen from many vantage points in Paterson, the best view is from Garret Mountain. The Third Watchung Mountain lies further to the west; it is not continuous and forms separated hills.

All three Watchung ridges are composed of basalt. They were carved by Nature from tilted sheet-like layers of solidified lava which were interbedded with much softer sandstones and shales. It took tens of millions of years for natural agents, such as changes in temperature, rainfall, running water, and others to loosen and remove the softer rocks. On Garret Mountain, sandstones and shales are exposed under the basalt along the eastern slope of the mountain.

Within the City of Paterson, the First Watchung Mountain is crossed by the Passaic River flowing through a water gap (this term is applied to the valley segment that crosses a mountain ridge). Another water gap is located in Little Falls where the Passaic River crosses the Second Watchung Mountain. The origin of these gaps, i.e., the explanation of how and when and by what river the solid ridges were cut, is still a matter of contention among geologists. Some geologists believe that several million years ago, an ancient river flowed over the lava sheets from which later the Watchung Mountains were carved. The Earth's crust was slowly rising in the area, and the river gradually cut its bed deeper and deeper into the basalt rock. At the time when the huge ice sheet invaded the area, the course of many rivers underwent changes and finally resulted in the present drainage pattern. In any case, today, the Passaic River flows through the water gap marked by the picturesque Great Falls, located in the place where the river crosses the zone of fractured basalt rock and water falls into one of the big cracks.

A part of the City of Paterson is built on the lower part of Garret Mountain, another part within the Passaic River water gap. The largest portion of Paterson lies on the lowlands which extend from the Hudson River to Alabama.

Old maps and pictures indicate that the landscape in Paterson has been greatly changed by man. The woody and hilly area around the Falls probably suffered most. A high hill, called Morris Mountain, towering on the site of today's Overlook Park, was destroyed by quarrying operations. Several years ago, Route 80 was constructed at the foot of Garret Mountain.

THE PATERSON AREA AND THE ICE AGE

The Watchung Mountains and its adjacent lowlands were already in existence before the Ice Age which started about 2 million years ago. Huge ice sheets, perhaps 2,000 feet thick, advanced from centers of accumulation in Labrador and south of Hudson Bay. The most recent glaciation extended farther than any previous glaciation, and its traces are found in northern New Jersey, including the Paterson area.

The ice sheet crept over the Watchung Mountains and the lowlands. Geologically speaking, the sheet retreated from the area very recently, some 10,000 years ago, leaving many relics.

"Sandy Hill" within the City of Paterson, is a relic of the Ice Age. The hill has a height of about 70 feet and is composed of sand, pebbles, cobbles, and boulders which were dumped by melt waters running off the retreating ice sheet and carrying sediments that were formerly trapped within the ice mass. Once Sandy Hill was larger and higher; but, was reduced by gravel quarrying and levelling for construction purposes. The school building (P.S. 15) was built on top of the hill, and its lower parts have been built up.

Another relic left by the ice sheet in Paterson is till which is an unconsolidated mixture of clay and sand containing numerous pebbles and boulders. This material was entrapped in the ice and was left on the ground surface as the ice melted. The till in the Paterson area is of a reddish color and its thickness varies.

Numerous "foreign" rocks (erratics) were brought by the ice sheet to the Paterson area from the hills of northern New Jersey, from New York State, and even from New England and Canada. Occasionally, fragments and boulders of fossil-bearing rocks are found. They were transported from the Catskill Mountains.

Many traces were left by the moving ice sheet on Garret Mountain; rocks were polished and scratched, and numerous erratics were deposited. These traces are described in detail in the chapter on the geology of the Garret Mountain Reservation.

PATERSON - A FAMOUS MINERAL LOCALITY

Hidden in the cavities and crevices of Paterson's basalt rock are minerals of rare beauty and variety; for example, amethyst, agate, pale green datolite crystals, white natrolite in needle crystals, and many others. The best known mineral is prehnite, usually occurring in bright-green, grape-like masses. These minerals were formed from chemicals dissolved in water which penetrated into openings in the solidified lava.

Minerals from Paterson were recorded by geologists as early as 1822. Very soon afterwards, they became famous among mineralogists of many countries and specimens found their way into the mineral museums of Europe and North America.

In the past, mineral collecting in the Paterson area was easy, as basalt was quarried in several places for its use in road construction. Previous to 1965 or so, mineral collectors had a chance to visit operating quarries and found good mineral crystals in newly opened quarry faces and freshly separated blocks of rock.

Unfortunately, it is not possible to collect minerals in Paterson today. No quarries are operating. The old quarries are built over or serve a different function. For example, the famous Upper New St. Quarry is now a junkyard. There is an operating quarry in the nearby town of Prospect Park; but it is not possible to obtain permission to collect minerals here.

The only opportunity to collect minerals in Paterson comes with new construction when the basalt rock is blasted and minerals which were hiding deep underground are now exposed. Good mineral specimens were recently collected during the construction of Route 80.

People interested in the geology and mineralogy of the Paterson area should not miss the opportunity to view the display of local minerals in the Paterson Museum; the result of half a century of collection, acquisition, and selection of the best mineral specimens found in the area. The Paterson Museum is located at 268 Summer St. (corner of Broadway); it is open on weekdays from 1 to 5 p.m. and from 10 a.m. to noon and 1 to 5 p.m. on Saturdays. It is closed on Sundays and major holidays.*

THE GEOLOGY OF THE GREAT FALLS OF THE PASSAIC RIVER

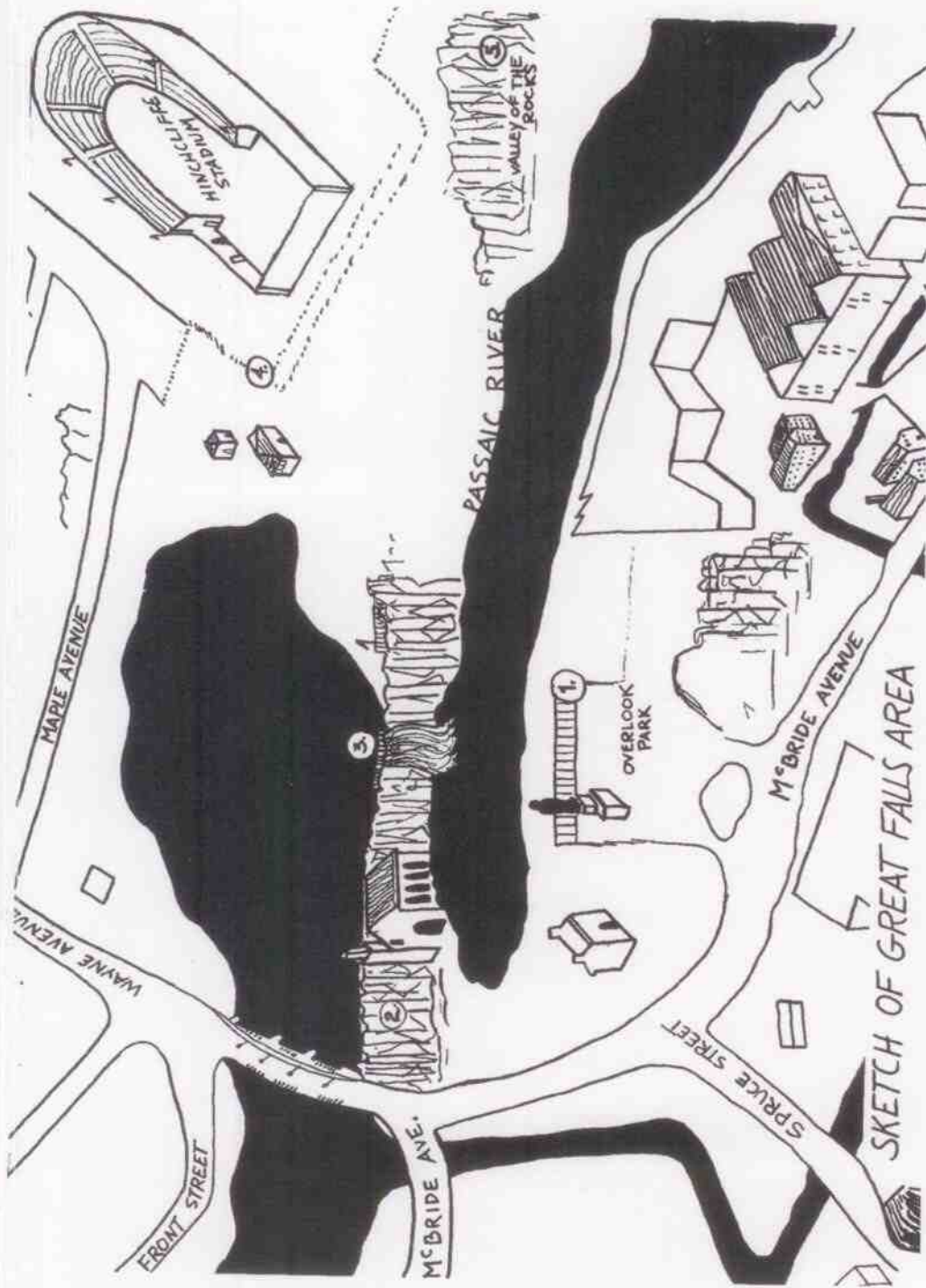
Inspired by the power of the roaring water of the Great Falls of the Passaic River, Alexander Hamilton reported to the New Jersey legislature in 1791 that he found an ideal site for manufacturing industries for the new nation.

The development of industry around the Great Falls is a good example of how geologic conditions control man's destiny. It is obvious that many areas have flourished because of their mineral wealth (iron ore, oil, and other minerals); Paterson, did not possess these industrial minerals but did have a ready energy source to operate its mills.

Rocks around the Falls bear evidence of many geological events that happened long ago and also of those that are occurring now. One can see the ancient lava flows and also observe these natural processes at work today, such as the erosion and weathering of solid rock.

Several sites in the vicinity of the Falls are described. Sites are numbered and shown on the succeeding sketch map.

*Interested readers may find detailed information on Paterson minerals in Brian Mason's book listed in the bibliography.



1. OVERLOOK PARK

Overlook Park is located high on the right bank of the Passaic River just below the Falls. It is a good place to see a general view of the Falls; the chasm into which the water is falling and the mighty erosion of solid rock.

Basalt rock formed from solidified lava is everywhere: in the cliffs over which the water cascades; and in the steep banks of the river. Basalt is also exposed as a towering rock at the entrance to Overlook Park and along the upper part of the road leading from the parking lot to the river.

Viewing the Falls gives an opportunity to see the results of interplay between internal forces within the Earth's crust and of the external forces of erosion and weathering. The former action of internal forces is manifested by the presence of the chasm and of numerous cracks or joints in the rock, mostly vertical. These cracks were caused by underground pressures millions of years ago. Large rectangular blocks of basalt are outlined in the cliffs.

Huge blocks and small fragments of basalt have fallen from the cliff and now lie in the water. This happened because of erosion, i.e., the wearing away of rocks by natural agents, such as falling and running water. Erosion worked its way along the joints and cracks and caused large blocks of basalt to fall from the cliffs. The chasm into which the water falls evidently developed from a huge crack widened by erosion.

Basalt rock is primarily dark gray in color; but, in places it has a yellowish or brownish color as a result of chemical weathering, i.e., changing of rock as a result of moisture and temperature changes. The exposed rock literally "rusts."

2. THE CLIFF ADJACENT TO THE ENTRANCE TO THE HYDROELECTRIC PLANT

Here basalt rock can be observed closely. Things to see:

a) The nature of the basalt rock is massive here. It is noteworthy, that basalt comes in several varieties; in part depending upon whether it was formed from the lower part of the lava flow (then it is massive), or the upper part of the flow where the rock is often divided into columns.

b) Chemical weathering: Here one can see the brown color caused by iron hydroxides formed from iron-bearing minerals in the basalt. A white coating of calcium carbonate is seen in places where ground water seeped through cracks in the rock.

c) Plants taking hold of bare solid rock: lichen, moss, ferns, grass, and small trees growing in crevices.

3. VIEWS FROM THE BRIDGE OVER THE FALLS

It is fun to stop on the bridge over the Falls, have your face sprinkled by water, to look closely at the roaring water.

Suppose we walk from Overlook Park (the right side of the river) to Great Falls Park (the left side of the river).

First, we see on the left, the cliff adjacent to the waterfalls which is a part of the peninsula formed by the bend of the river. Water does not fall over this cliff but it looks as if the water is seeping through the rock on several different levels. This is river water circulating through cracks in the rock.

In the cliffs, joints and slickensides are seen in the basalt. Slickensides are polished and smoothly striated surfaces that result from friction along a fault plane along which rock masses have moved.

To the left is a good view of the chasm and the falling water. The beauty of the view depends heavily on recent weather; the Falls thunder mightily after a heavy rain, but during dry periods, the Falls may be reduced to a mere trickle.

4. GREAT FALLS PARK

Great Falls Park located on the left bank of the Passaic River adjacent to Hinchcliffe Stadium is a good place to closely observe the chasm into which the water falls and to learn about such geological features as fractures, faults, and fault zones.

Let us begin our observations at the very end of the Falls near the two small red brick buildings. Go down the stairs leading from the picnic area to the river's edge.

In the river bed above the Falls, we see in places the protruding uneven surface of the basalt. Then the river bed is crossed by the chasm into which the water falls. Let us walk along the stone fence to the right. Here the chasm forms a fork. One branch is cut by the stone dam. The other branch, closer to the viewer, gradually becomes more narrow and shallow, and finally ends. Numerous cracks in the rocks stretch parallel to the chasm justifying the name "fault zone."

The walls of the chasm are primarily uneven but in places they are very smooth, as if polished. These are slickensides caused by friction when rock masses moved along these cracks.

5. VALLEY OF THE ROCKS

The left bank of the Passaic River below the Falls has been known for many years as the "Valley of the Rocks." Once the Lenape Indians camped and fished in this valley and tradition tells us that the huge rock close to the river's edge was one of their favorite fishing places and even today is known as "Bass Rock."

Many geologists have examined this site and the Valley of the Rocks is mentioned in several books on the geology of New Jersey. This is the best place in the Falls area to see several varieties of typical lava rock, as well as the underlying sandstones and shales over which the lava once flowed. Here one may collect lava fragments millions of years old which look the same as lava formed in volcanoes active today.

The height of the cliff opposite the animal shelter is about 130 feet. Two kinds of rock can be seen here: reddish colored sandstone on the bottom and gray basalt(solidified lava) on the top.

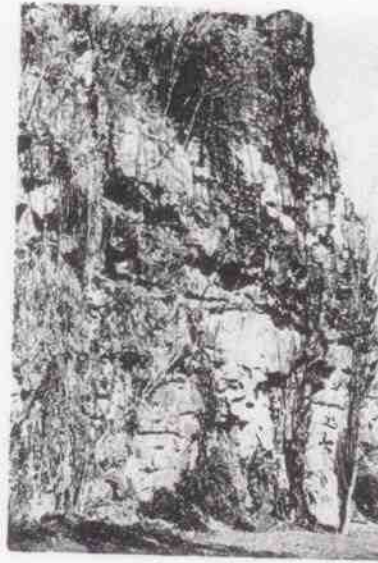
Sandstone, as its name implies, is a rock formed from sand. During the "Age of Dinosaurs," there were streams flowing in the area carrying mud and sand. When the velocity of the water decreased, both the mud and sand were deposited as sediments. Later the layers of sand were compressed and cemented to form sandstone. The mud was compressed to form shale. One can clearly see layering in the sandstone; this is why sedimentary rocks are also called "layered rocks." In some layers of the sandstones, rounded stones called pebbles are seen. They have been rounded and smoothed by rolling along the stream bottom when the water velocity was high. It is interesting to observe the bedding within each sandstone layer, i.e., the arrangement of each layer in thin beds of varying thickness and character. Beds are for the most part parallel to each other, but in some places small thin beds are inclined in straight sloping lines at various angles. This phenomenon is called cross-bedding and was produced by changing currents of water.

Shale is exposed in several places in the cliffs of the Valley of the Rocks, usually as irregular small masses in sandstone. It is characterized by very thin laminae(layers). Shale is rather easy to identify, as it can be split into thin flat pieces.

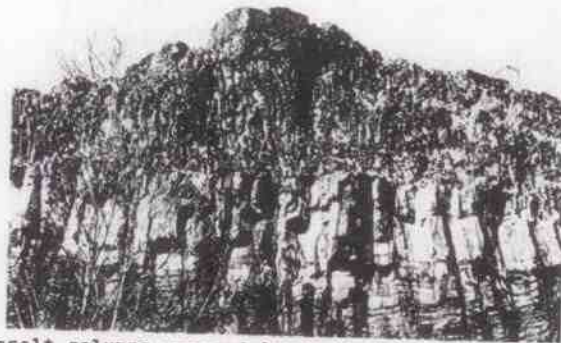
Layered rocks in the Valley are overlain by gray basalt. One can imagine how during the "Age of Dinosaurs," hot liquid lava moved over the Earth's surface, over the sand and mud, and then gradually cooled and turned into rock called basalt. The contact surface between basalt and the underlying sandstone and shale is clearly seen.

A general view of the cliff gives an opportunity to see the columnar structure of the basalt. These natural basalt columns are known from many parts of the world; the most famous is "Giants Causeway" in Ireland. These parallel prismatic columns, generally six-sided in cross section, 10-20 feet high, were formed as the result of the contraction of rocks during the cooling of the lava.

Several prominent geologists have studied and described this exposure of the lava flow. There are three zones clearly seen, divided horizontally. The lowest zone, just above the sandstone, looks massive, without columns or joints. Perceptive people may see that in places the basalt is porous and includes cavities filled with white minerals. Higher up, the second zone is composed of coarse, rather regular columns, 10 to 20 feet high. The third zone consists of much more slender, wavy columns. Geologists think that these zones developed at the time



A general view of the cliff in the Valley of the Rocks. Basalt is on the top; layered sandstone and shale on the bottom.



Basalt columns exposed in the Valley of the Rocks: a zone of coarse rather regular columns at the bottom; slender wavy columns on the top.

of cooling and solidification of the thick lava flow. The rate of hardening varied at different depths. While a part of the flow had already solidified, the other part was still liquid and hardened later. During the cooling process, different types of columns developed in each zone or none at all.

A chaotic mass of loose fragments and large blocks of basalt and sandstone lie at the base of the cliff adjacent to the road near the animal shelter. It is easy to identify certain blocks of basalt as having come from one of the three zones described above.

A large block of rock about three yards in diameter lies in front of the animal shelter. It is clearly seen that this huge rock fell from the lowest zone of the lava. A close look at this rock mass may convey some details of the events of some 190 million years ago, at a time of volcanic activity in the area. An observer can see the contact between the sedimentary rock and the lava, as well as fragments of red shale and sandstone enclosed in the lava rock. It is easy to imagine the boiling lava rolling over the ground or probably over the river or lake bottom and encompassing lumps of sand and mud. Near the contact, both the lava rock and sandstone contain numerous small cavities, and look spongy in places. Geologists think that these cavities may be the result of steam from moisture in the sediments being rapidly released to the atmosphere, or may be due to air entrapped beneath the lava. Here, specimens of the porous lava can be collected.

THE GEOLOGY OF THE GARRET MOUNTAIN RESERVATION

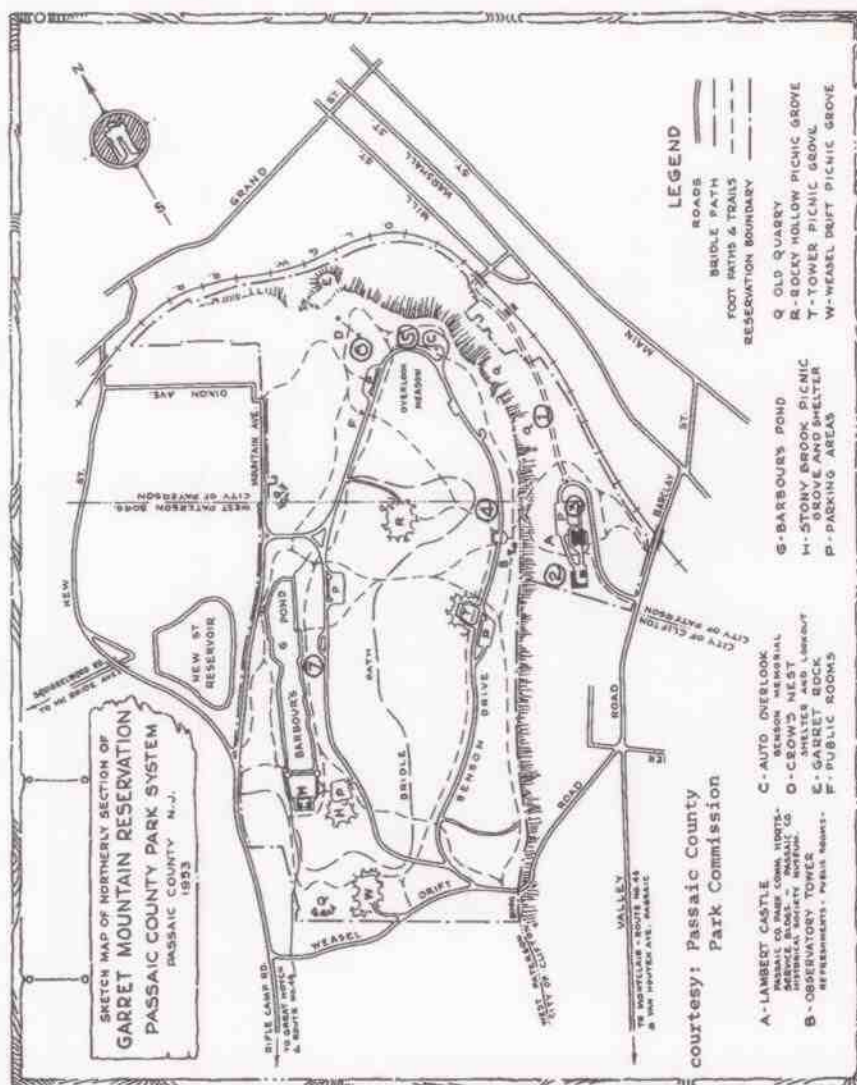
The Garret Mountain Reservation, located on the First Watchung Mountain, is a good place to see landforms and rocks. A trip can be planned in several ways: 1. the group may ride in a bus around the Reservation and get out for observations as the bus stops in parking areas; 2. the group may proceed on foot through the Reservation; and 3. the group may visit selected sites.

Several sites are described below. Corresponding numbers are indicated on the site map.

1. THE CLIFF AT THE SLOPE OF GARRET MOUNTAIN NORTH OF LAMBERT'S CASTLE

A magnificent almost vertical cliff showing the cross section of Garret Mountain parallel to its ridge is located approximately 900 feet north of Lambert's Castle. The area is restricted and both groups and individuals should ask permission beforehand to visit the site by calling the Passaic County Park Police at telephone (201) 278-2233.

The cliff rises some 80 feet over the artificially leveled ground and presents an excellent view of the rocks that comprise Garret Mtn. Reddish sedimentary rocks lie at the bottom. Sandstone is found in layers several feet in thickness. It is hard and feels gritty when handled. Shale comes in much thinner layers and in lens-shaped bodies.



It easily crumbles and breaks into thin plates. As its name implies, sandstone formed from the consolidation of sand; shale formed from mud.

An igneous rock, basalt, is exposed in the upper part of the cliff and differs sharply from the underlying sedimentary rocks. Basalt formed from the solidified lava which some 200 million years ago poured over the sedimentary rocks.

Basalt is massive with many joints (cracks). Primarily, basalt is of a dark gray color; but, there are also brown, orange, and greenish colorations. These colorations indicate chemical weathering; iron-bearing minerals occurring in basalt "rust," i.e., iron combines with oxygen from the air and water and forms compounds of a brownish color.

The upper part of the right-hand section of the cliff shows curvilinear columns formed as the result of contraction of the lava during cooling.

Occasionally, ground water emerges from the cracks both in the basalt and the sandstone.

Sandstone was once quarried in the area and used for construction in Paterson and the vicinity. Traces of an old quarry, now overgrown by vegetation, are seen on the slope to the right of the cliff.

The greatest part of the cliff runs parallel to the ridge of Garret Mountain and it seems that all the layers of the sedimentary rocks are horizontal. At the left, however, the rock exposure becomes almost perpendicular to the ridge showing a cross section of the Garret Mountain slope. Here, it is clearly seen that the layers of the sedimentary rocks are gently tilted towards the north-northwest at an angle of about 15-20 degrees. This is direct evidence that millions of years ago, after the lava had broken through the Earth's crust and had solidified, there were strong movements within the Earth's crust in the area. Both the basalt and the sedimentary rocks which had been flat lying, now were tilted.

Numerous blocks and fragments both of basalt and sandstone lie at the foot of the cliff, witness to the fact that solid rock has been gradually eroded, i.e., destroyed by changes in temperature, wind, and rainfall. Such loose broken rock is called talus.

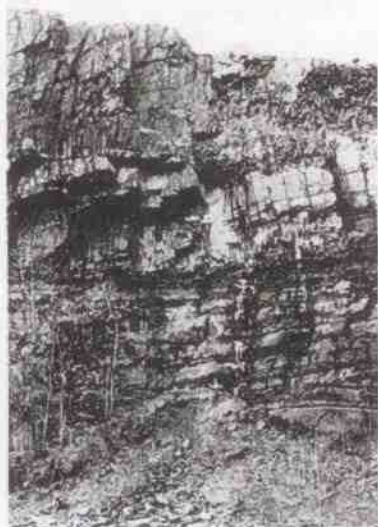
It is not advisable to come too close to the cliff. Sandstone and shale specimens can be easily collected at a small outcrop at the right side of the road leading from the described cliff to the Castle.

2. THE SLOPE OF GARRET MOUNTAIN IN FRONT OF LAMBERT'S CASTLE

This site is especially good for the observation of the traces of sliding of the huge blocks of basalt.

The upper part of the slope is very steep; the lower part is gentle and heavily overgrown by thick vegetation. Many more details can be seen at a time when the foliage is not full.

A trail from Lambert's Castle goes uphill to the Observation Tower on the top of Garret Mountain.



The cliff at the slope of Garret Mountain, north of Lambert's Castle. Basalt is on the top; sandstone is on the bottom.



A smooth vertical rock surface (slickenside) adjacent to the trail leading from the Observation Tower to Lambert's Castle.

The cliff below the tower is almost vertical and evidently represents a fault scarp, i.e. a surface along which there has been a vertical displacement of rock along a fracture. In some places the surface of the rock is polished and smoothly striated (slickenside) as a result of friction when huge rock blocks slid down below the vertical cliff. Some of them are still leaning towards the cliff, other lie on the slope.

3. VIEW FROM LAMBERT'S CASTLE TERRACE

A view of the lowlands opens from the terrace adjacent to the castle. The lowlands are a part of the Piedmont Physiographic Province which extend from the Hudson River to Alabama. When visibility is good, the Palisades and the New York City skyline are seen along the horizon.

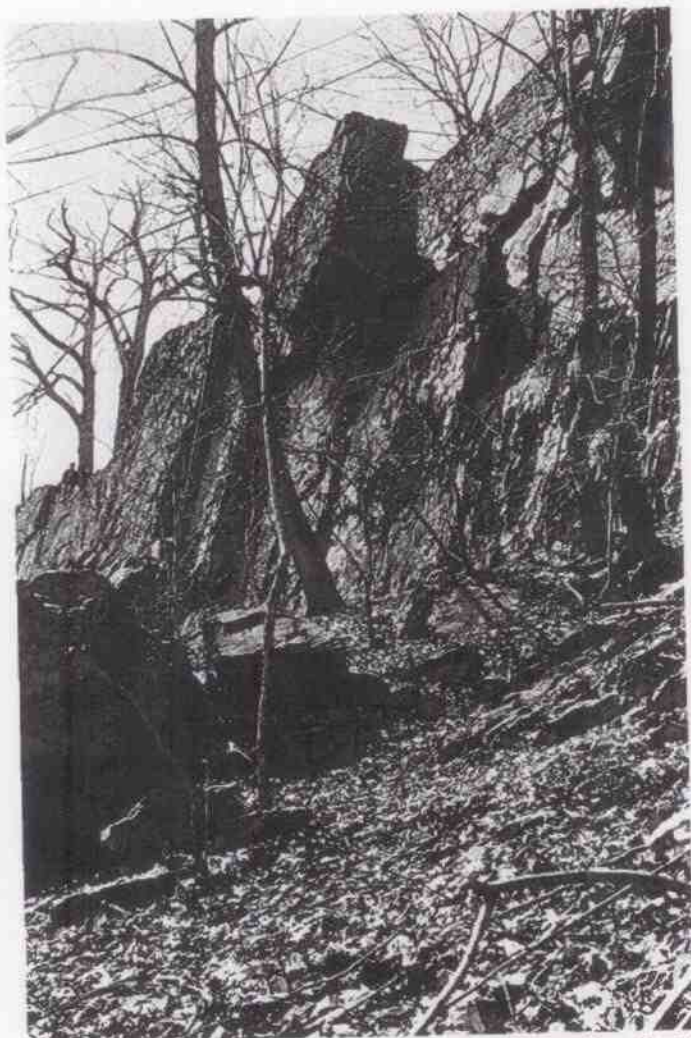
Luckily, Sandy Hill in Paterson is seen in any weather. It is of interest as a relic of the Ice Age (see description on p. 3).

4. THE AREA AROUND THE OBSERVATION TOWER

The Observation Tower stands on the summit of Garret Mountain on the basalt. Many things can be seen in the area revealing some events of its geological history: volcanic activity resulting in the formation of basalt; earthquakes which caused the appearance of faults; and the invasion from the north of the continental ice sheet.

Evidence of the Faulting

Faults can be clearly seen in several places near the Observation Tower. They appear as vertical smooth basalt cliffs beneath the Tower on the side overlooking Paterson. Several fault planes can also be observed while walking on the trail leading from the courtyard adjacent to the Tower towards the parking lot of Lambert's Castle. As one enters the trail through the opening in the stone fence, he immediately sees to the left a very smooth vertical rock surface (slickenside). Then the slope is overgrown with vegetation. A fault zone with several exposed faults is seen near the sharp turn in the trail. Huge steps with very smooth vertical surfaces are clearly seen on the slope. The "turning point" on the trail is the best place for observations. Looking in the direction of Observation Tower, one sees almost vertical walls of basalt; in places smooth; in places curvilinear. Huge rectangular blocks of basalt are lying on the lower part of the slope. A few of them are still attached to the cliff.



The cliff of Garret Mountain below the Observation Tower revealing cracks in the rocks and slickensides.

Evidence that the Area was Covered with the Ice Sheet

A. Erratics. We have already mentioned that the upper part of Garret Mountain is composed of basalt. However, numerous rock fragments, both angular and rounded of various rock compositions and sizes occur on the surface of Garret Mountain. These are called ERRATICS and they were brought to the area by the ice sheet from the hills of northern New Jersey, from New York State and even from New England and Canada. Two large granite boulders, one of them up to two yards high, occur on the slope between the Observation Tower and the adjacent parking lot. Most erratics, however, are of smaller sizes.

Students may learn to distinguish these "foreign rocks" from basalt and to make a collection of rocks brought here by the glacier.

B. Glacial Grooves. These are deep, usually straight furrows, cut in bedrock by the rock fragments embedded at the base of a moving glacier. Numerous grooves occur on the surface of basalt around the Observation Tower. The Tower itself stands on the rock with clearly seen grooves developed along the joints and the cracks in the rock.

C. Glacial Pavement. This is a polished, striated, relatively smooth planed-down rock surface produced by the mechanical wearing of rock due to the weight of moving ice. Such a pavement can be observed at a distance of about 100 feet from the Observation Tower parking area near the road going in the direction of Clifton.

5. AUTO OVERLOOK ON GARRET MOUNTAIN

The view from the Auto Overlook and adjacent area is the best in the Garret Mountain Reservation. The broad lowland stretches to the east. If visibility is good, the Palisades and the New York City skyline are seen along the horizon to the east, and the Ramapo Mountains to the north. The Highlands on the other side of the Hudson River are seen on days when visibility is especially good. The Passaic River with the Great Falls can always be viewed (the easiest way to locate the Falls is by finding Hinchcliffe Stadium). Also Sandy Hill in Paterson is always visible (see its description on p. 3).

The surrounding rock is basalt. In the area where the stone fence ends northwards from the parking lot, there is a glacial pavement with striations. The slope of Garret Mountain does not fall abruptly here, as it does along the ridge, but presents a rounded rock ledge that formed due to the action of the ice sheet. Farther north, numerous rock fragments, pebbles and gravel occur on the flat slope. Some of this material is local basalt, but the majority are erratics brought by the ice sheet. There are several big boulders here, exceeding two yards in size.

Some large boulders were put to use by the landscape architects: they border the parking area. A fence stretching lower on the slope is made of smaller boulders.



The glacial pavement near the Crow's Nest parking area. This erratic composed of sandstone was brought by the ice sheet from a nearby valley.



This erratic brought by the ice sheet from the Highlands remained in this position after the ice melted.



An erratic on Garret Mountain near the Auto Overlook; it was carried by the ice sheet from the Highlands.

6. CROW'S NEST (SHELTER AND LOOKOUT)

Huge boulders are placed at both sides of the steps leading from the parking lot to the shelter and lookout. Most of these boulders are composed of granite and gneiss, i.e. rocks foreign to our area where basalt is the bedrock. They were evidently found somewhere nearby and are erratics brought by the ice sheet.

Having reached the top of the steps, turn left. At a distance of some 100 feet there is a glacial pavement - a large area of relatively smooth rock surface polished by the ice sheet. Two large erratics composed of reddish sandstone lie on the pavement. The other area of glacial pavement occurs near the trail to the Crow's Nest Lookout.

A stone shelter offers an excellent view of many landforms of Northern New Jersey: the Passaic water gap, the Great Falls, First and Second Watchung Ridges, the Ramapo Mountains, and others.

The trail goes over the rocky surface from the stone shelter towards the auto overlook. The basalt here is somewhat different; mineral grains can be seen with the naked eye. The rock breaks down into small columns, several inches long with sides of about one inch. Some columns occur in very regular shapes, eventually forming threesided prisms.

7. BARBOUR'S POND

A. The Trail Along the Pond at the Side of the Parking Area

Basalt that comprises Garret Mountain is seen everywhere. This is the bedrock. Pebbles and rock fragments other than basalt lying on the ground surface are foreign to the area and were brought here by the ice sheet. Part of the trail is covered by crushed granite brought here by man.

Vertical basalt cliffs are seen on the opposite side of the pond. The smooth surfaces of the cliffs bear witness to the downward movement of rock masses along the fracture in the rock (faulting). In this way a depression was formed which is now filled with water.

Erratics up to two yards in size occur on the northern shore of the pond near the bridge.

B. The Trail Along the Pond on the Side Opposite to the Parking Area

The trails go over the basalt rock. Slickensides, i.e. smooth surfaces resulting from friction as rock masses slid along fault planes, can be seen.

THE GEOLOGY OF WESTSIDE PARK

Paterson's Westside Park lies on the left bank of the Passaic River upstream from the Great Falls. A small brook crosses the park and empties into the river. Observation of the muddy water of the brook conveys an understanding of the geologic work done by brooks and rivers. Tiny rock particles carried by the brooks and rivers are suspended in the water;

they later settle on the river or ocean bottom as mud; the mud being later transformed into clay or shale.

The park is located on the bottom of the Passaic River gap (see p. 2) and the bedrock here is basalt. The basalt is hidden under soil overgrown with grass but can be observed in detail on the rocky part of the hill on the right bank of the brook near the spot where it empties into the Passaic River.

Basalt is massive, gray, and in places yellowish due to weathering (see p.21). The side of the hill overlooking the river is almost vertical. Two perpendicular systems of joints (cracks) are seen in the basalt rock. Huge naturally formed steps occur in several places. Smooth rock surfaces indicate that in the past, rock masses slid down along the walls of fractures. Thus it is evident that this hill is located in a fault zone.

It is worthwhile to climb to the top of the hill in order to get an insight as to how the famous Paterson minerals occur in nature. The surface of the basalt here is uneven and somewhat weathered. Numerous holes 1-2 inches in diameter are seen in the rock. They are filled with whitish minerals, which are also weathered and therefore hard to identify. Probably, attractive minerals are hiding inside the hill and in the basalt under the soil in the park. When the foundation was laid for the adjacent Kennedy High School and the basalt was blasted, many good mineral crystals were found in cracks and holes in the basalt.

The ice sheet invasion left its marks in Westside Park in the form of huge boulders. A granite boulder about two yards in diameter lies near the submarine (to the left if one looks at John Holland's plaque). Another granite boulder, about 1.5 yards high, marks the site of the Military Road used by George Washington.

GEOLOGY IN THE INNER CITY

This chapter is not meant to be a guide to the geology within the City of Paterson but rather it intends to give basic information concerning some geological features which are seen while touring the city.

A large portion of Paterson rests on sandstones and shales which are rarely seen, except during building construction. However, layers of tilted reddish-brown sandstone may be seen in the left slope of the roadcut upon entering Paterson via Route 80 from the east, just after passing the sign "Welcome to Paterson." These rocks can be also observed on the lower part of the slope of Garret Mountain near Lambert's Castle, in the Valley of the Rocks (see p. 8), and on McBride Ave. near the Overlook Park, on the right side going uphill.

In the last century and early part of this century, reddish-brown sandstone, commonly called "brownstone," from Paterson and other localities, was widely used for buildings, stone fences, and retaining walls. There were several of these brownstone quarries located in Paterson. Buildings built of brownstone in Paterson are: St. John's Cathedral on Main Street, Church of the Messiah and Our Lady of Victories on Broadway, and Lambert's Castle.

The hilly part of the City of Paterson is built on basalt or solidified lava, which is seen on many streets and in backyards on both slopes of the Passaic Water Gap: on the right slope in the area of Grand Street and New Street, and on the left slope in the area of Belmont Ave, West Broadway, Maple Street, and others. Cliff Street is probably one of the most picturesque. It starts behind the Matlock housing projects and winds up the steep slope. Houses stand on the basalt and the cliffs tower in backyards. At the corner of Cliff and Arlington Streets, glacial pavement covers part of a yard.

In the chapter entitled "The Paterson Area and the Ice Age" (p. 3) I described relics left by the ice sheet in Paterson. The most prominent is a depository of glacial drift known as "Sandy Hill"; but, the most common feature is till. This reddish unconsolidated sediment containing numerous boulders covers the sandstone and shale or basalt bedrock.

Boulders transported to Paterson by the glacier are permanently "displayed" in the city in stone fences and retaining walls. These "displays" are especially numerous in the "Sandy Hill" area. Boulders vary in composition, because they were brought by the glacier from many different localities lying north of Paterson.

GEOLOGICAL FEATURES IN THE PATERSON AREA OF INTEREST TO SCHOOL CLASSES*

1. THREE MAIN GROUPS OF ROCKS: IGNEOUS, SEDIMENTARY, AND METAMORPHIC

At the time when students are studying the three main groups of rocks, it is advisable to show them examples of these rocks in the field and to ask them to collect rock specimens.

Igneous and sedimentary rocks occur in the Paterson area as bedrock; which means the solid rock that is part of the crust of the Earth. The igneous rock, basalt, which formed as lava solidified, can be observed in many places in Paterson. Layered sedimentary rocks, sandstones and shales, can be observed best in the Valley of the Rocks, near the Great Falls, and in the cliff north of Lambert's Castle.

Metamorphic rocks do not occur in the Paterson area as bedrock; but, they are common as boulders and pebbles lying on the ground surface. They were brought by the ice sheet from the areas lying to the north. The Garret Mountain Reservation is a place to collect specimens of metamorphic rocks, primarily gneiss.

NOTE: It is advisable for teachers to prepare a "Paterson" rock collection for classroom use. If students use hammers to break rocks, goggles must be worn to protect their eyes. Learn to recognize man-made materials common in urban areas (slag, glass, concrete, and others).

* See detailed descriptions in the chapters on the geology of the Garret Mountain Reservation and the Great Falls area.

2. EROSION

Erosion, i.e. wearing away of rocks by natural agents, can be observed in many places around Paterson. At the Great Falls, one can see erosion caused by the action of falling and running water. On the slopes of Garret Mountain, erosion is caused by rainfall and the down-slope transport of soil and rock material.

3. WEATHERING

Weathering, i.e. changing the character of rock by exposure to atmospheric agents, can be clearly observed on the exposed basalt. Primarily dark-gray in color, basalt often has a yellowish color due to chemical changes in the iron-bearing minerals contained in basalt. Many boulders and rock fragments lying on the ground are weathered. They may be altered just on the surface, or they may be weathered throughout. While collecting rock specimens, students should not include weathered specimens in their collections.

4. EVIDENCE OF EARTH CRUSTAL MOVEMENTS IN THE AREA

Tilted rock layers can be seen in the cliff north of Lambert's Castle. Fractures in rocks can be seen in the Great Falls area, in the Garret Mountain Reservation, and in Westside Park. Also faults and slickensides can be observed in these places.

Faults are surfaces or zones of rock fracture along which there have been displacements. Slickensides are polished and smoothly striated surfaces that result from friction as rocks move along the fault plane.

5. EVIDENCE THAT THE AREA WAS COVERED WITH THE ICE SHEET

Garret Mountain Reservation is the best place to observe relics of the Ice Age, namely:

Erratics, i.e. rocks other than local rocks; they were brought to the area by the Ice Sheet.

Glacial Grooves, i.e. deep furrows cut in bedrock by the rock fragments embedded at the base of the moving glacier.

Glacial Pavement, i.e. a polished, striated, relatively smooth rock surface produced by the mechanical wearing of rock due to the weight of the moving ice.

6. LANDFORMS

Several sites in the Garret Mountain Reservation present excellent views. Numerous landforms can be observed, such as the lowlands; Sandy Hill in Paterson; the First and Second Watchung Ridges; the Palisades; the Ramapo Mountains; and the Highlands on the other side of the Hudson River.

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